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ION'S
MATE'S COMPANION,
OR
NAVIGATION AS PRACTISED AT SEA.

THE

MATE'S COMPANION;

OR,

Navigation as Practised at Sea,

WITH NUMEROUS

RULES AND EXAMPLES WORKED OUT,

ILLUSTRATING

ALL THE SHORTEST SEA METHODS

OF THE

PRACTICAL BRANCHES OF NAVIGATION

AND

NAUTICAL ASTRONOMY,

WITH THE

TABLES REQUIRED FOR FINDING THE LATITUDE BY THE POLE STAR; MOON; AND LATITUDE AND LONGITUDE BY SUMNER'S METHOD; LONGITUDE AT SUNRISE OR SUNSET.

DEVIATION OF THE COMPASS PRACTICALLY ILLUSTRATED.

By M. ION.

SECOND EDITION,

REVISED AND AUGMENTED BY HIS SON AND SUCCESSOR,

C. J. ION,

TEACHER OF NAVIGATION, &C.,

56 NELSON STREET, GREAT GEORGE SQUARE, LIVERPOOL.

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PREFACE TO SECOND EDITION.

In reproducing this work, I feel convinced I am conferring a great benefit upon many seafaring men.

The chief object of the work has been to enable those who may have been neglected in early life by way of education, to get hold of short and easy methods of obtaining what they daily require at sea, viz :—"The Ship's Position," and the "Compass Error."

The hope of being of some service to the seafaring population has been the chief inducement in the preparation of this work; and if this end is fulfilled the desire of the author and his successor has been accomplished.

C. J. ION.

56, *Nelson Street, Liverpool.*
January, 1883.

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THE

MATE'S COMPANION,

OR,

NAVIGATION AS PRACTISED AT SEA.

THE COMPASS.

The Mariner's Compass consists of a circular card divided into 32 equal parts, called points, which are subdivided into half and quarter points. On the under side of this card is attached the magnetized bar or needle, poised on a pivot, so as to swing freely, pointing in the direction of the North Pole.

There are only few places *(of no variation)* where the needle points exactly to the true north. When it points to the eastward of the true north it is easterly variation. But when the north point of the needle is attracted to the west of north, it is called westerly variation.

There is also, especially in iron ships, another disturbing force called local attraction, which will be treated of hereafter in examples illustrated practically.

N.B.—The Examples in this book are worked by the 1871 Almanack, but those unable to procure it can use any fourth year since, viz., '75, '79, or '83, with almost similar results.

Westerly variation is allowed to the left of all magnetic bearings or courses sailed by compass, to get the true bearing or true course, before they are laid off on a chart that has no magnetic compass on it. The Channel charts now published have only the magnetic compass, therefore the variation is not required, as you use the bearings or courses by compass as they are; for example, cross-bearings, you find Orme's Head bearing by compass S.E., and Point Lynas S.W., then take S.E. to Orme's Head, and to Point Lynas S.W., and where they cross each other on the chart is the ship's position when the bearings were taken. To find the distance off one point of land, take its bearing, and run with it abeam a distance and get its bearing again, lay both bearings off on the chart, then slide the course in the parallels up the two bearings until the distance she run in the dividers agree with each bearing, and one point of the dividers will shew where she was, the other point where she is now.

To lay off the ship's position on the chart. When the latitude and longitude is known, lay the parallel rulers on the nearest parallel of latitude marked on the chart, and move them carefully to the latitude required, then, with the dividers, take the longitude, which bring to the edge of the parallel ruler and set it off, which will shew the ship's position.

To shape a course from the position just found to any place of destination, lay the edge of the parallel rulers on the ship's place and that of her destination, and move them carefully to the nearest compass, which will shew the true course, and will require westerly variation allowed to the right hand to get the compass course or course to sail *(mind that)*; for example, if the true course found is South, and two points west variation, you will sail S.S.W. to make it.

If the chart has a magnetic compass on it, then the magnetic course is shewn at once, which would be in the above case S.S.W., no variation required.

THE LOG-LINE AND GLASS.

The Sand Glasses used are the 28 seconds and the 14 seconds or short glass; the latter is used when the ship is sailing fast, and gives half the speed only; doubled, you have the rate the ship is going.

THE LOG-LINE

IS DIVIDED INTO EQUAL SPACES, CALLED KNOTS.

The knots are divided into half knots.

The length of a knot depends on the number of seconds the glass runs, and must therefore be the same part of a sea mile as the seconds are of an hour of time.

TO FIND THE LENGTH OF A KNOT.

Rule.—Annex a cypher to the number of seconds run by the glass and divide by 6, the quotient will be the proportional length of a knot in feet. After dividing by 6, any remainder is doubled for the odd inches.

Example.

Required, the length of a knot for a glass running 28 seconds :—

6)280

46·4
2

Ans.— 46·8 = **Forty-six feet eight inches.**

For a glass running 14 seconds would be half of the above—23·4.

Required, the length of a knot for a glass running 20 seconds :—

6)200

33·2
2

Ans.— 33·4 = Thirty-three feet four inches.

THE SHIP'S RECKONING.

Leaving a port, you will note the Bearing of any object the Latitude and Longitude of which is known or found upon the chart; this bearing and your estimated distance off is laid upon the chart (using the opposite point o. the bearing), which will mark the position of the ship when you took the departure.

The courses sailed, and the distance run on each course, will be carefully entered on the log slate, and when applied to the chart separately from the place she was at when the departure was taken, will give you her position at any time required.

In sailing from a port like Liverpool, you will find the first and second day's work, page (34), sufficient to illustrate the proceedings required, being careful to note and allow for the drift of the current between the English and Irish coasts. You will also notice that a departure has been taken at Holyhead *(South Stack)*, Bardsey, and the Smalls Lighthouse, in order to work with the first, providing either of the latter cannot be seen. If an altitude of the sun for time could be had when the departure is taken, you will then find how the error of your chronometer agrees with that given you from those who have had charge of it in Port.

You will now be put into a position requiring some knowledge of—first,

PLANE SAILING, which is sailing on one course, making both difference of latitude and departure, except when sailing due N. or. S., then the distance sailed is all difference of latitude.

TRAVERSE SAILING is sailing on different courses, which have to be reduced to a single course and distance by a traverse table, as you find under all the days' works in this book.

PARALLEL SAILING.—You make no difference of latitude as you are sailing on a due east or west course, making all departure, which is turned into longitude, by taking the latitude as a course, and seek for the departure *(or distance run)* in a latitude column, against which, in the distance column, you have the difference of longitude to apply to the longitude of the place you left, as follows :—

Example.

Longitude left 48° 40′ W., the departure made or distance sailed West in latitude 30° 00′ N. was 52 miles, required the longitude in.

Longitude left	48°40′ W.
Lat. 30° and dep. 52′ in a lat. col. gives 60′	= 1·00 W. in a distance column.
Longitude in.....	49·40 W.

If a ship sails East or West on the equator, the departure the ship makes is the difference of longitude, 60 miles to the degree. But if she sails East or West on any other parallel of latitude, the degree of longitude will be less than 60 miles, and less in proportion as you approach the poles.

The following table will shew the number of miles there is on every parallel of latitude from the equator to the poles :—

LATITUDE.	MILES.	LATITUDE.	MILES.	LATITUDE.	MILES.
1°	60·0	31°	51·4	61°	29·1
2	59·9	32	50·9	62	28·2
3	59·9	33	50·3	63	27·2
4	59·8	34	49·7	64	26·3
5	59·8	35	49·2	65	25·4
6	59·7	36	48·5	66	24·4
7	59·5	37	47·9	67	23·4
8	59·4	38	47·3	61	22·5
9	59·3	39	46·6	69	21·5
10	59·1	40	46·0	70	20·5
11	58·9	41	45·3	71	19·5
12	58·7	42	44·6	72	18·5
13	58·5	43	43·9	73	17·5
14	58·2	44	43·2	74	16·5
15	58·0	45	42·4	75	15·5
16	57·7	46	41·7	76	14·5
17	57·4	47	40·9	77	13·5
18	57·1	48	40·2	78	12·5
19	56·7	49	39·4	79	11·4
20	56·4	50	38·6	80	10·4
21	56·0	51	37·8	81	9·4
22	55·6	52	36·9	82	8·4
23	55·2	53	36·1	83	7·3
24	54·8	54	35·3	84	6·3
25	54·4	55	34·4	85	5·2
26	53·9	56	33·6	86	4·2
27	53·5	57	32·7	87	3·1
28	53·0	58	31·8	88	2·1
29	52·5	59	30·9	89	1·0
30	52·0	60	30·0	90	0·0

LATITUDE BY OBSERVATION.

When near noon, take the altitude of the sun's lower limb, and watch until it is done rising, correct this the meridian altitude for index error, and take it from 89° 48′ when it exceeds 40°,

if less than 40° you may use 89° 50′; this gives the sun's meridian zenith distance, call it the opposite name to the bearing.

Then correct the sun's declination from the Nautical Almanac for the Longitude, or Greenwich time by table 21 Norie, according to the rules at top of the table.

When the zenith distance and the declination are both the same name, add them for the latitude.

If they are contrary names (one north and the other south,) subtract them, and call the latitude same name as the greater.

NOTE.—The 89° 48′ is 90°, with the semi-diameter less the dip and refraction (12′) taken off, which corresponds with adding 12 to the altitude before taking it from 90°.

When the altitude is less than 40°, the refraction is so large, and being subtractive as well as the dip, reduces the semi-diameter down to about 10′, &c., thence 89° 50′, which is 90° less 10′.

Examples.

Sept. 19th, 1871.. 89°48′ Longitude 6° W.	Oct. 1st, 1871.... 89°50′ Longitude, 45° W.
Observed altitude 40°11′ S. of the observer.	Observed altitude 30°10′ S. of the observer.
Zenith distance .. 49°37′ N., opt. to bearing.	Meridian zen. dis. 59°40′ N.
⊙ declination.... 1°33′ N., cord. for 6° W.	⊙ cor. declination 3°10′S.cord.for3h.or45°W
Latitude..... 51°10′ N., af. the greater.	Latitude..... 56°30′ N., af. the greater.

N.B.—A little practice in correcting the sun's declination, with the difference for 1h. given against the declination in the Almanac. Rule.—Turn the longitude into time, and divide the minutes by 6 to get the tenth of an hour, then multiply the hourly difference by the longitude in time; cut off the decimals, and what is left is the correction to be applied as before. Declination increasing, add the correction in west longitude, subtract in east. Declination decreasing, subtract the correction in west longitude, add in east.

Example 1st, above.

Sept 19th, dec. 1°33′29′ N., h. diff. 58″·3	
Correction..... — 23 long. 6°=24m ·4	
Cord. declination 1°33′06 N.	23·32

NOTE.—Longitude above being 6° turned into time gives 24m, which, divided by 6, gives 4 tenths.

Example 2nd, above.

Oct. 1st.....dec. 3°·07′·00″ S., h. diff. 58″·3	
Cor. for 45° or 3h. + 2′55, long. 45°=3h. 3	
Cord. declination 3° 9′55 S.,	6,0)17,4·9
	2·55

Longitude above being 45°=3h, multiply by 3, and having no decimal but what is in the hourly difference, cut that off only, and divide by 60.

LATITUDE FROM THE MERIDIAN ALTITUDE OF A FIXED STAR

Can be found very frequently with great accuracy, and is of very great advantage in high latitudes in winter time, when the sun is not to be had on the meridian for several days in succession. It is said that we shall require to know the different stars by a Planisphere, or some other laborious system of finding them, but I fancy an officer has, during his infancy at sea, got to know something of that part of his education while walking the deck at night, and I can scarcely imagine that there is a sailor afloat that does not know Aldebaran, *alias* (a Taurus,) or the Bull's Eye, if you like. Now, this good old star is decidedly a winter star in the North Atlantic, and seems to have been designed for special use in that Ocean during winter, for in the summer months you cannot get it on the meridian if you wanted it, simply because it does not come to the meridian but when it is daylight. Now if you don't know Aldebaran, you will first clap your eye on *Pleiades*, or the *Seven Stars*, in the same constellation (Taurus), from which S.E.b.E. 14°* lays the star Aldebaran, of the first magnitude, and is easily known by a reddish appearance. It passes the meridian about 9 p.m. on the 1st of January, and on a clear night you may get your latitude from his meridian altitude to about the 1st of March, after which you will have to do without Aldebaran until the end of September, when you may again see him on the meridian just before daylight.

* This distance of fourteen degrees is an estimated measurement carried in the imagination, from having noticed the space between the object and the Horizon when taking its altitude.

A little practice will enable an observer to judge the distance between stars in all the books containing directions for finding fixed stars. (See page 53, Thomson's Tables.)

LATITUDE BY THE STAR ALDEBARAN.

1871.—January 1st, about $9^H\ 20^M$ P.M., I found Aldebaran would rise no higher than 55° 40′ S., which I take as his meridian altitude, eye about 16 feet, and sextant adjusted.

Rule.—Take the true altitude from 90°, and find the latitude by the usual Rules.

Altitude obs. = 55°40′ south of the observer.	
Cor. for dip & ref.	— 4
Stars true alt.	55°36′
	90
Zenith distance	34°24′ N.
Stars decl. N. alk. 16°15′ N., or fr. Ion's Alk. 1871, p. 8.	
Latitude.....	50°39′ N.

LATITUDE BY THE POLE STAR.

Latitude by the Pole Star, *a Ursæ Minoris*, or *Polaris*, lays about a degree and a half from the North Pole, and can be used for finding the latitude as readily as any other star.

If the Pole Star were exactly at the Pole, its altitude would be the latitude; but as it is not on the Pole, its altitude has to be increased when below the Pole, and decreased when above the Pole. The amount of this correction to be applied after the dip and refraction will be found in Table (1), as follows :—

Rule.—To the sun's right ascension for the day in the Nautical Almanac, add the apparent time at ship, rejecting 24 hours when the sum exceeds that number, for the right ascension of the meridian; with which enter the table in one of the side columns that it can be found in, then, opposite to which

in the centre column, you have the correction in degrees and miles, to be applied to the true altitude of the star, as directed at the head of the table.

Examples.

1871, Sept. 20th.—At 8H. P.M. apparent time at ship, the observed altitude of Polaris was 50°30′. Required the latitude.

Sun's right ascension,	11H. 49M.	Observed altitude	50°30′
Apparent time at ship,	8H. 00M.	Dip and refraction	— 4′
Right ascen. meridian,	19H. 49M.	True altitude.....	50°26′
		Correction, table 1	— 15′
		Latitude.....	50°11′ N.

1871, January 1st.—At 4H. 3M. A.M., at ship, the observed altitude of the star Polaris was 44°56′. Required the Latitude.

Sun's right ascension,	18H. 47M.	Observed altitude Polaris	44°56′
Time at ship.....	16H. 3M.	Correction for dip. & ref.	— 5′
	34H. 50M.		44°51′
	24H.	Correction, table (1)...	+1°08′
Right ascen. merid.	10H. 50M.,	Latitude	45°59′ N.

LATITUDE BY THE MOON'S MERIDIAN ALTITUDE.

Rule.—Reduce the Moon's Meridian passage at Greenwich to the place of observation by Table 16 Norie, or by proportion; viz., get the difference between the day's passage and the following, if West Longitude; if East Longitude, the difference between the day and day previous,—with which enter table 16 at top, and the longitude at side, for the correction to be applied as directed at head of Table (2)

NOTE.—When the Meridian passage in the Almanac exceeds 12 hours, take the preceding day's passage (*mind that*) and also the date.—See example worked on page 16.

When the Meridian passage is reduced to the ship's place, it will be the mean-time at ship at the instant the Moon is on the meridian, to which add your Longitude if West, or subtract if East, for the Greenwich time, and correct the Moon's declination for that day and hour by the 10^{M} difference for any odd minutes of time.

To the observed altitude, corrected for index error, apply the correction from Table (2) as directed at top, for the true altitude of the Moon, which take from 90°, and find the latitude by the usual rules. Same name add, contrary names subtract, and call the Latitude after the greater.

Example.

1871. January 1st.—In Longitude 30° West, the Moon's Meridian Altitude, lower limb, was 55°30′ bearing South. Required the Latitude.

	H.	M.
Moon's Meridian Passage, Jan. 1st..	8	13
Cor., Table 16 Norie* for 44m & 30° W	+	4
Moon's Cor. Mer. Pass. or M. T. Ship	8	17
Longitude 30° W. in time	2	00 W.
Mean time at Greenwich, Jan. 1st.	10	17

Moon's Decl., Jan. 1st., at 10H = 12°39′51″N.
Correction for 17M, see work below + 2′47″
Moon's Corrected Declination.... 12°42′38″N.
Moon's Horizontal Parallax .....54′

Moon's Observed Altitude	55°30′ S.
Corr. for par. 54′ and alt. 56°, table (2)	+ 40′
Moon's True Meridian Altitude	56°10′
	90°00′
Moon's Meridian Zenith Distance....	33°50′N.
Moon's Corrected Declination	12°48′N.
Latitude	46°38′N.

	M.	″
Change of Moon's Declination in 10	=	98·44
Multiply by 1·7, which will give Corr. for 17M		1·7
		68900
		9844
		6,0)16,7,348
Correction for 17M to add above....		2·47

* Difference between the Meridian passage of the 1st and 2nd January is 44M. at top of Table 16 Norie, and 30° at side, gives correction 4M. to add.

LATITUDE BY MOON'S MERIDIAN ALTITUDE.

Examples.

1871, January 19th.—In Longitude 157°45′ West, the observed Meridian Altitude of the Moon's upper limb, bearing North, was 70°6′. Required the latitude.

	H. M.		
Meridian Passage, 18th Jan.....	= 22 41	Moon's declination 19th, at 9H...	23°5′07″ S
Correction, Table 16 Norie	+ 26	Correction for 38M.....	— 20
Red. Meridian Passage 18th....	23 07	Moon's red. declination	23°4′47 S.
Longitude in time.....	+ 10 31 W.		
	33 38		
	24		
Greenh. mean time, Jan. 19th =	9 38	Moon's Hor. Parallax.....	59′ 40″

		M.	″	
Observed altitude, upper limb,...	70°06′ N.	Difference for 10 =	5·2	
Correction from table (2)	0		3·8	
True altitude.....	70 06		416	
	90		156	
Zenith distance.....	19 54 S.	Correction for 38M	19·76	say 20′
Redd. declination	23 05 S.			
Latitude	42 59 S.			

1871, March 9th.—In Longitude 30°00′ East, the Moon's Meridian Altitude, *(upper limb,)* was 50°10′ bearing North. Required the latitude.

Ans.—39°46′ S.

1871, August 16th.—In Longitude 60°00′ West, the observed Meridian Altitude of the Moon's lower limb was 58°08′, bearing South.

Ans.—47°34′ N.

LONGITUDE BY CHRONOMETER, AT SUNRISE OR SUNSET.

Rule.—When the Sun is rising or setting, note the time by Chronometer, when either the upper or lower limb is in contact with the horizon.

Correct the declination, find the polar distance, and reduce the Latitude to the time of observation.

From the sum of the Latitude and polar distance subtract 21′, if the lower limb has been taken, and then divide by 2. To this half sum add 21, which call the remainder, and find the time with the usual Logs.

NOTE.—If the upper limb is taken, then you subtract 53′, and add 53′, as stated above—for 21′ when the lower limb is observed. *(Mind this.)*

Example.

1871, December 1st.—In Latitude 35° 35′ North, the Sun's upper limb was observed on the horizon setting, when a Chronometer shewed

TIME BY CHRONOMETER.		SUN'S DECLINATION.		H difference....	23″5
8H. 30M. 10S. P.M.		H. M.	21°47′56″S.	Greenwich time..	8·5
		Correction for 8 30	+ 3 20		1175
		Corrected decin. ..	21 51 16		1880
			90		6,0) 19,9,75
		Polar distance.....	111 51 16	Correction....	3·20
Latitude.....	35°35′	Secant.....	0·08977		
Polar distance	111 51	Co-secant.....	0·03238		
Sum.....	147 26			M. S.	0·94
Subtract.....	— 53			Eq. time....10 53	8·5
	146 33			Correction.. — 8	470
Half sum	73 16	Cosine	4·45927	Red. eq. time 10 45	752
Add.....	+ 53				7,990
Remainder.....	74 09	Sine	4·98317		
App. time at ship..	4 58 16	= Log	9·56459		
Equat. time.....	— 10 45				
Mean time at ship..	4 47 31				
Mean time Greenh.	8 30 10				
Longitude in time	3 42 39	= 55°39′45″ W.			

LUNAR OBSERVATION.

When you have a Chronometer, proceed as follows to find its error.

To the time at Greenwich reduce the Moon's Horizontal Parallax, the Moon's Semi-diameter, and augment it by Table 4, Thomson. Now proceed as follows by Rules on page 10, Thomson, problem III.

Example.

TIME BY CHRONOMETER.	ALTITUDE ⊙'s	ALTITUDE ☽'s.	OBSD. DIST. NEAR LIMBS.
	29°48′	16°20′	⊙☾ .. 120°59′10″
H. M. S.	Add..... + 12	Subtract.. — 20′	⊙'s semi-diam. +16 18
1871 Jan. 1st.— 0 27 30			☽'s aug. semi. + 14 50
	⊙'s app. alt. .. 30°00′	☽'s ap.alt. 16°00′	Ap. distance 121 30 18

Moon's hor. parallax. ..	54′07″	Log — 0619	.....		0619	Tables.
⊙'s apparent altitude..	30 00	Log — 7610	☽'s app. altitude	16°0′	1·0197	14
						15
Apparent distance....	121°30′18″	Log S. 9308	Log T.....		1·2127	16
First correction.....	4 28 16	Log — 1·7537				and
Second correction....	4 50 52	.....		Log	2·2943	17
Third correction	+ 3 31	Table 18.				

True dist., less 10°, =	120 52 57			
Distance in N. Alk....	120 40 33	Pro Log N. Alk...	3470	
Difference.....	0 12 24	Pro Log Table 19..	1·1619	See Rules, pages 14 and 15, for finding Greenwich time from the true distance.
	H. M. S.			
Pro. part of time.....	0 27 34	Pro Log Table 19..	0·8149	
Time over first distance	0 0 0			
M. time at Greenwh..	0 27 34	January 1st.		
Time by the Chronomtr.	0 27 30	January 1st.		
Chronometer slow...	0 0 4	for Mean Time at Greenwich.		

NOTE.— To the Altitude of the Sun's lower limb add 12′ for the apparent altitude, and from the Moon's upper limb take 20′, for its apparent altitude add 12′ to her lower limb.

To the observed distance apply the index error, when any, and add the Sun's semi-diameter and the Moon's augmented semi-diameter, for the apparent distance; when the remote limb, subtract the semi-diameter, then see Rules, page 10, Thomson.

N.B.—When there is no Chronometer, you will first find the mean time at ship from the altitude of the Sun or Star as usual, and correct all from the Nautical Almanac, with an approximate Greenwich time found with ship time and longitude by account. Having got the mean time at Ship, and mean time at Greenwich by the Lunar, their difference is the Longitude as usual.

LUNAR OBSERVATION

(NO CHRONOMETER.)

In Latitude 35° 1C South, Longitude 62° 30′ East.

1871.—January 1st, P.M., at Ship. The following observation, between the Sun and Moon, was made for finding the mean time at Ship from the Sun's Altitude, and the mean time at Greenwich by Lunar :—

H. M.				
January 1st.—4 40 P.M.	Alt..... ⊙'s 29° 48′	Alt.....)'s 16° 20′	Obsd. dist...120°59′10″N.L.
Longitude....4 10 E.	Cor. ..... + 12	Cor. ..... — 20′	⊙'s semi-dia. + 16 18
			)'s aug. semi + 14 50
G. T., Jan 1st, 0 30	⊙'s App. Alt... 30 00	)'s App. alt.... 16° 00′	App. dist. ..121 30 18

Sun's apparent altitude ..	30°00′		Sun's declination 23°1′28″ S.	12″3 H. diff.
Refraction	— 1		Correction ..... — 6	0,5
Sun's true altitude	29 59		Cor. decln. 23 1 22	6,15
Latitude	35 10	Log 0·08752	90 0 00	
Polar distance	66 59	Log 0·03603	Polar dis. 66 59	
Sum.....	132 08			
Half sum.....	66 04	Log 4·60818		
Difference	36 05	Log 4·77009		
	H. M. S.			
Apparent time at ship ..	4 34 24	Log 9·50182		
Equation of time ..... +	3 45			
Mean time at Ship.....	4 38 09	January 1st.		

To find the True Distance and Greenwich Time.

Moon's hor. parx. ..	54′07″	Log....0619		0619	TABLES. 14, 15, 16, & 17, Thomson
Sun's app. alt.	30°00′	Log....7610	)'s Apparent altitude 16°00′ =	1·0197	
App. distance ..	121°30′18″	Log S..9308	Log T.....	1·2127	
First correction ..	4 28 16	Log..1·7537			
Second correction	4 50 52			2·2943	
Third correction.. +	3 31	Table 18.			
Tr. dist. less 10° =	120 52 57				
Dis. in N. Alk. ..	120 40 33	Pro. Log ·3470	Nautical Almanac.		
Difference	0 12 24	Pro. Log 1·1619			
	H. M. S.				
Pro. part of time	0 27 34	Pro. Log 0·8149			
Time over 1st dis.	0 0 0	Nautical Almanac.			
M. T. at Greenh..	0 27 34	January 1st.			
M. time at Ship ..	4 38 09	January 1st.			
Longitude	4 10 35	= 62°38′45″ E.			

LATITUDE AND LONGITUDE BY DOUBLE ALTITUDES.

SUMNER'S METHOD.

Now it will often happen that the Sun cannot be had on the Meridian for several days together, while there may be chances of getting an Altitude for Time in the morning or afternoon (or both), and to make such observations of service, we put them into practice by what is called Sumner's Method.

Two Latitudes are assumed, one on each side of that by account, viz., the degree next less and next greater. We should then, with two altitudes at different times in the forenoon, or one in the forenoon and one in the afternoon, get four Longitudes, two for each degree of Latitude, and lines drawn from the positions on the lesser degree to the positions of the greater degree will cross each other, and where they intersect is the ship's position at the time of taking second observation.

Example.

1871, September 20th, A.M., at Ship, between the Latitudes 45° and 46° North, when a Chronometer shewed as follows:—

H. M. S.

TIMES.. { 8 36 31 A.M., the altitude of the ☉'s was 21° 31′
{ 10 36 30 A.M.. the altitude of the ☉'s was 38° 21′

Eye 12 feet. Required the latitude and longitude at the second observation.

Mem.—When the Observations are made in the Morning, take the hour angle from 12H. for the apparent time at Ship.

	FIRST ALTITUDE. LATITUDE 45° AND 46°.				SECOND ALTITUDE. LATITUDE 45° AND 46°.			
	21°31′		21°31′		38°21′		38°21′	
Correction...	+ 10		+ 10		+ 11		+ 11	
True altitude	21 41		21 41		38 32		38 32	
Latitude	45 00	Log 0·15051	46 00	.. 0·15823	45 00	.. 0·15051	46 00	.. 0·15823
Polar distance	88 47	Log 0·00010	88 47	.. 0·00010	88 48	.. 0·00010	88 48	.. 0·00010
Sum	155 28		156 28		172 20		173 20	
Half sum....	77 44	Log 4·32728	78 14	.. 4·30947	86 10	.. 3·82513	86 40	.. 3·76451
Difference ...	56 3	Log 4·91883	56 33	.. 4·92136	47 38	.. 4·86855	48 08	.. 4·87198
	H. M. S.		H. M. S.		H. M. S.		H. M. S.	
Hour angle ..	3 59 38	Log 9·39672	3 57 20	= 9·38916	2 2 37	= 8·84429	1 55 41	= 8·79482
Ap. T. at Ship	8 00 22		8 2 40		9 57 23		10 4 19	
Equa. of time	— 6 28		— 6 28		— 6 30		— 6 30	
M. T. at Ship	7 53 54		7 56 12		9 50 53		9 57 49	
M.T. at Greenh	8 36 31		8 36 31		10 36 30		10 36 30	
Long. in time	0 42 37	= 10°39¼ W.	0 40 19	= 10°4¾′ W.	0 45 37	= 11°24¼′ W.	0 38 41	= 9°40¼′ W.

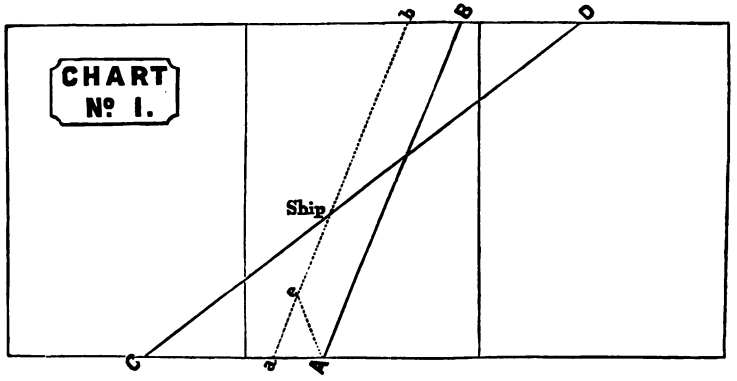
CHART
№ 1.
Ship
C
a
A
B
D

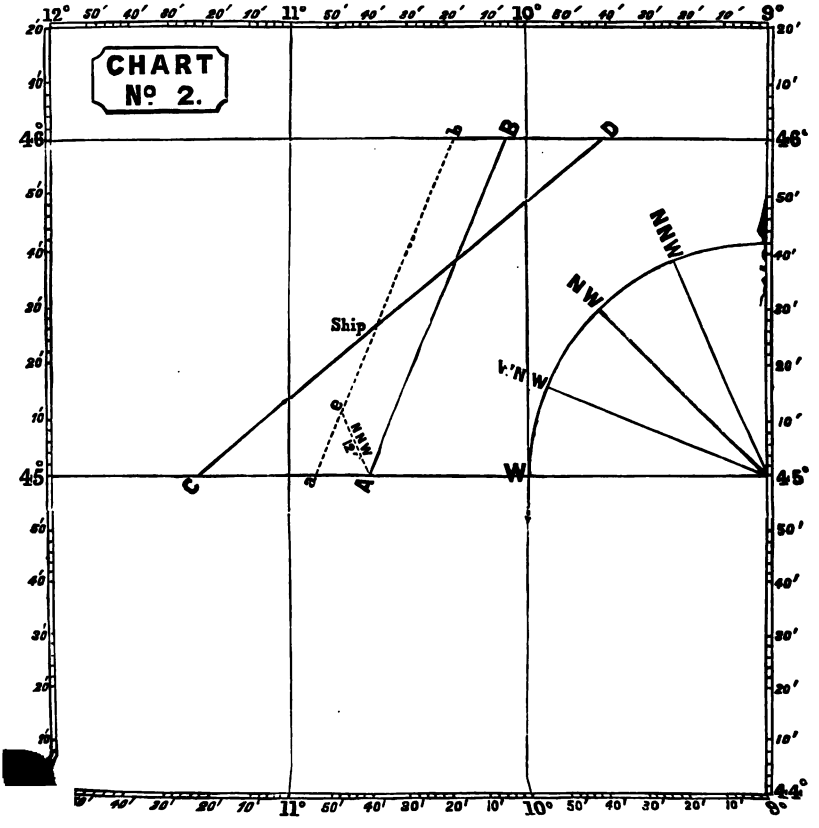
CHART
№ 2.
Ship
C
a
A
B
D
NNW
NW
W.N.W
W
12°
11°
10°
9°
46°
45°
44°

DIAGRAM CHART.

In the foregoing Example the Ship is considered to have been stationary during the interval between the observations, but as that will seldom or ever occur, except in a calm, we must be able to reduce the first observation to what it would be if made at the place of the second observation; and the first of several methods is this, viz., set off from the position (A) the course and distance the Ship has made good (during the time that elapsed between taking the first and second Altitude) and mark this (e); now take the line (A B) in the parallel rulers and carry it to (e), and draw the line again, and where this line (a b) intersects the line (C D) is the position of the Ship when the second observation was made.

Example.

Suppose that in the former case the Ship had sailed during the interval North *(two points West variation)* 12 miles, (corrected N.N.W. 12 miles,) where will the Ship be when the second observation was made?

(See Chart No. 1.)

Latitude 45°, Longitude 10° 39′ West, and 11° 24′ West.
Latitude 46°, Longitude 10° 05′ West, and 9° 40′ West.

Corrected Course N.N.W., 12 miles.

(See Chart No. 2.)

HOW TO CONSTRUCT A CHART.

NOTE.—(See Chart No. 2) will also illustrate the construction of a Chart.

Lay the Meridians off 60 miles apart from a scale of equal parts, and graduate the degrees into miles, marking every 10′, 20′, 30′, &c.

The Parallels of Latitude must be laid off as many miles apart from each other as Table 3 will give for the corresponding degrees of Latitude.

Parallel 44° Meridional Parts, Table 3, Norie.....	2946
Parallel 45° Meridional Parts, Table 3, Norie.....	3030
Distance for the spread of Parallels, 44° and 45°	84
Parallel 45° Meridional Parts, Table 3, Norie.....	3030
Parallel 46° Meridional Parts, Table 3, Norie.....	3116
Distance for the spread of Parallels, 45° and 46°.....	86

SUMNER'S METHOD.—*Continued.*

It may happen that only one observation can be had for time, (*that is,*) while waiting for the Sun to change its bearing sufficient

for the second observation; the Sun may be obscure. Well, in that case some service can be made of the single observation by working it with two Latitudes, one on each side of that by account, and mark off the Longitude the sight gives, on each parallel of Latitude, draw a line from one position to the other, calling one (A) and the other (B), as before.

Now if that line (A B) is extended or drawn longer on the Chart until it reaches the coast, you obtain the bearing of that land the line runs into, and consequently know the course to, but not the exact distance off, as you don't know exactly on what part of the line (A B) you are, although aware that you are somewhere on it; and as that is something worth knowing, let us see it more clearly by the following Example :—

1871, June 22nd, at 8 A.M., at Ship. Between the parallels of Latitude 50° and 51°, the Sun's Altitude of the lower limb was 35° 17′, when the Chronometer shewed 8H. 21M. 21s. A.M. at Greenwich. Required the Longitude of the Ship on the parallel of 50° and 51°, and what part of the coast will the extended parallel of equal altitude reach to?

June 22nd ⇒ 8H. 21M. 21s. A.M., altitude ☉'s 35° 17′, ☉'s declination 23°27′N.
Correction... + 10 90

Sun's true Altitude... 35 27 Polar distance 66 33

True altitude	35°27′			35°27′		
Latitude	50 00	...	0·19193	51 00	...	0·20113
Polar Distance	66 33	...	0·03744	66 33	...	0·03744
Sum	152 00			153 30		
Half-Sum	76 00	...	4·38368	76 30	...	4·36819
Difference	40 33	...	4·81299	40 3	...	4·80852
	H. M. S.			H. M. S.		
Hour-angle	4 08 45	=	9·42604	4 5 21	=	9·41528
	12			12		
App. time at Ship	7 51 15 A.M.			7 54 39 A.M.		
Equa. of time	+ 1 32			+ 1 32		
Mean time at Ship	7 52 47 A.M.			7 56 11		
Mean time at Greenh.	8 21 21 A.M.			8 21 21		
Longitude	0 28 34	=	7° 8½′ W.	Longitude... 0 25 10	=	6° 17½′ W.

The Longitude 7° 8′ W. laid off on the Parallel of 50° mark A.
The Longitude 6° 17′ W. laid off on the Parallel of 51° mark B.
A line drawn from A. to B. and extended, runs into the Smalls, therefore you have the course to the Smalls. See chart, No. 3.

* MEM.—An error occurs in the working by Latitude 51°, viz., 40° as the difference instead of 41°, and it has been considered best to let it remain, as it will not affect shewing the Rules, but shew the necessity of avoiding such errors when so near the land, especially *in thick weather, when* the consequences might be very serious if the *Lead* is not kept in *frequent use, and a good Look-out.* Keep plenty of water under the ship, and hit nothing *that's afloat.*

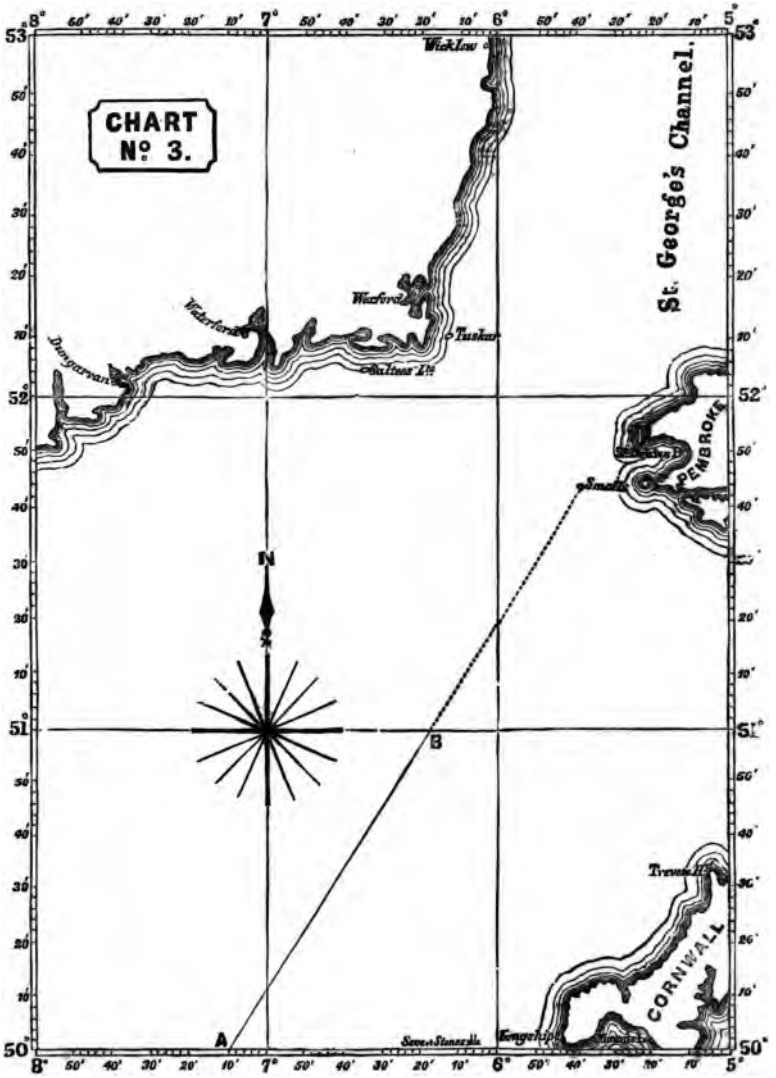
CHART
No. 3.
St. George's Channel.
Wicklow
Waterford
Wexford
Tuskar
Dungarvan
Saltees Lts
PEMBROKE
Smalls
N
A
B
CORNWALL
Scilly Is.
Longships
Lizard

FINDING THE LONGITUDE BY EQUAL ALTITUDES OF THE SUN AT NOON.

From ten to twenty minutes before Noon observe an Altitude, and note the time by Chronometer. Again, when the Sun has passed the Meridian, and fallen to the same altitude, note the time by Chronometer. Add these two Chronometer times together, and take half their sum. To this apply the error of the Chronometer, as usual. To this mean time apply the corrected equation of time the reverse way from the direction in the Nautical Almanac, page 1st, which reduces it from mean to apparent time, and is the Longitude in time at Noon.

Example.

1871, June 10th.	H.	M.	S.
Sun's Altitude A.M., 65° 10', Chronometer time	4	10	10
Sun's Altitude P.M, 65 10, „ „	4	41	04
	2)8	51	14
Half sum.....	4	25	37
Chronometer slow	+	5	10
Mean time at Greenwich when Sun is on the Meridian ...	4	30	47
Equation of time corrected, Almanac says subtract, hence	+	0	56
Longitude in time.....	4	31	43
Longitude turned into space	67	55	45 W.

This short method of Equal Altitudes, although not absolutely correct, is very useful at times, and gives the Longitude very nearly. With a little practice and careful attention, and when the Sun is high, you need not be far out of the way. *(Mind that.)*

NOTE.—In the Morning three Altitudes at different times should be taken, in case the sun might be clouded at the time the afternoon Altitude is sought for, which will give three chances of securing the Longitude.

DEVIATION OF THE COMPASS.

The Deviation of the Compass is the difference between the variation of the Compass at the place of Observation and that found to exist in the Ship.

The variation of the Ship's Compass is found by taking the difference between the bearing of the Sun, or a Star, and its true bearing found by the true Azimuth Tables. (*Burdwood's*)

The variation found will be known to be West when the true bearing is to the left of that observed; or East, when the true is on the right of that observed.

Now, if the variation found is more than it should be at the place of Observation, its excess is deviation of the same name as the variation.

If the variation is deficient of what it should be, What it is short is deviation of a contrary name to the variation.

(1.)—For Example, 1871, June 1st. In Latitude 50° 00′ N., at 5 P.M., the Sun's bearing by Azimuth Compass was N. 61° 30′ W. Ship's head S.W.; Variation at the place 23° 30′ W.

At page 205, Azimuth Tables, Latitude 50° N., Sun's declination 22° N. gives true Azimuth	N. 86° 21′ W.
Sun's bearing by Azimuth Compass	N. 61 30 W.
Variation and deviation combined	24 51 W.
Variation at the place, per Chart	23 30 W.
Deviation of the Compass for the S.W. point	1 21 W.

(2.)—1871, June 2nd, at 5H. 40M. P.M. Latitude 50° N., when the Ship's head was S.E., the Sun's bearing by Compass was N. 59° W. Required the Deviation: Variation at the place 23° 30′ W.

Answer, 3° 29′ East,
For the S.E. point of the Compass.

1871, December 31st, at 2H. P.M. Latitude 50° N., when the Ship's head was N.E., the Sun's bearing by Compass was S. 48° 30′ W.; Variation at the place being 23° 30′ W. Required the deviation.

Page 209, Azimuth Tables, gives Sun's true bearing N. 151° 54′ W. { Lat. 50° N. / Dec. 23° S.
180 00

or, S. 28 06 W.
Bearing of the Sun by Compass..... S. 48 30 W.

Variation of the Ship's Compass..... 20 24 W.
Variation at place of observation, per Chart 23 30 W.

Deviation of the Compass for the N.E. point ..... 3 06 East.

1871, December 11th, at 10H. 40M. A.M. In Latitude 50° N., when the Ship's head was East the Sun's bearing by Compass was South. Variation at the place 23° 30′ W. Required the deviation.

Answer, 4° 29′ Easterly.
For the East point of the Compass.

1871, December 11th, at 3H. 20M. P.M. Latitude 50° N., when the Ship's head was N.W. the Sun's bearing by Compass was S. 71° 30′ W.; Variation per Chart at the place 23° 30′ W. Required the deviation.

Answer, 2° 58′ Westerly.
For the N.W. point of the Compass.

1871, September 23rd, at 9H. 0M. A.M. At Ship, in Latitude 41° N., when her head was E.N.E. the Sun's bearing by Compass was S. 40° 30′ E.; Variation at the place 20° W. Required the deviation.

Answer, 3° 46′ East,
For the point E.N.E.

1871, February 1st, at 10H. A.M. In Latitude 39° S., when the Ship's head was North, the Sun's bearing by Compass was N. 54° 00′ E.; Variation at place 4° 25′ E.

Deviation, 0° 0′,
For the point North.

Deviation of the Compass, found from the bearing of a Star whose declination does not exceed that in the tables, viz., 23° N. or 23° S.

Rule.—To the astronomical time at Ship add the Sun's Right Ascension, for the Right Ascension of the Meridian. From the Right Ascension of the Meridian take the Star's Right Ascension (borrowing 24H if necessary) for the Star's hour angle or Meridian distance West.

If the remainder be more than 12 hours, take it from 24^H, and the result will be the hour angle East of the Meridian. Should the remainder be more than 24^H take 24^H from it, and the result will be the hour angle West of the Meridian.

The above Rules refer to finding the Meridian distance or hour angle when the time at Ship is known.

If the hour angle has to be found from a Chronometer shewing Greenwich time, then, after its errors are applied, subtract Longitude in time if West, add if East, for the mean-time at Ship.

Take the sidereal time from page 2 of the month, and accelerate it for the Greenwich time, and add the mean-time at Ship to it, from this sum (increased by 24^H, if necessary,) subtract the right ascension of the Star; the remainder will be the Star's hour angle West of the Meridian. If the remainder be greater than 12^H take it from 24^H, and the result will be the hour angle East of the Meridian.

Should the remainder be more than 24^H reject 24 hours, and the result will be the hour angle West of the Meridian.

N.B.—The hour angle of the Star must always be taken from the right hand side, under apparent time P.M.

From the apparent time being the time kept at sea, the first will be found the most simple in practice.

The rules for a Star will also find the hour angles of the Moon or a Planet.

East of the Meridian, in reference to the bearing at foot of the pages, will go for A.M., and West for P.M.

Example.

1871, March 21st, at 10H. P.M. Apparent time at Ship, in Latitude 40° N., steering S.S.E., the observed bearing of the Star Aldebaran was N. 60° 30′ W. Required the deviation; Variation at the place being 23° 00′ W.

	H.	M.
Sun's right ascen..	0	2
App. time at ship	10	0
Rt. ascen. meridian	10	2
Star's right ascen..	4	29
Star's hour angle..	5	33 W.

Latitude ..... 40° N.
Star's declination 16 N. } gives true bearing...N, 81° 54′ W.
H. M.
Star's hour angle 5 33 } Bearing by compass N. 60 30 W.

Deviation and variation combined	21	24 W.
Variation on the chart	23	00 W.
Deviation for the S.S.E. point of the Compass..	1	36 E.

1871, December 2nd, at 5H. A.M. In Latitude 44° N., steering W.S.W., the observed bearing of the Star Sirius was S. 68° W.; Variation at that place 23° W. Required the deviation.

	H.	M.
Sun's right ascen..	16	29
App. time at ship..	17	00
	33	29
Star's right ascen...	6	39
	26	50
Less	24	
Star's mer. distance	2	50 W.

Latitude..... 44° N.
Declination..... 16½ S. } gives True Azimuth N. . 137° W.
H. M.
Hour angle..... 2 50 }

180

or S. 43 W.
Star's bearing by compass S. 68 W.

Whole deviation and variation combined	25	W.
Variation on the chart	23	W.
Deviation for the point W.S.W.	2	W.

1871, September 8th. At 8H. 00M. P.M. at Ship, Latitude 41° S., steering South, the observed bearing of Markab was N. 80° E.; Variation at the place 23° W. Required the deviation.

	H.	M.
Sun's right ascen..	11	06
App. time at ship..	8	00
Rt. ascen. meridian	19	06
	24	
or	43	06
Star's right ascen ..	22	58
	20	08
	24	
Star's hour angle..	3	52 E.

Latitude..... 41° S.
Declination..... 14½ N. } gives the True Azimuth S. 122 E.
H. M.
Star's hour angle 3 52 E. } 180

or N. 57 E.
Bearing by compass....N. 80 E.

Deviation and variation combined	23	W.
Variation at place of observation	23	W.
No deviation for the South point of the Compass	0	

CURRENT SAILING.

In St. George's Channel (or anywhere else) it will be essential to the safety of life and property, to take the effect of the Current into account, which varies in its rate per hour, according to Neap or Spring Tides. For example, if I was taking a departure from the South Stack, and shaping a course for Tuskar, when it was exactly low-water at Liverpool, I *should* be aware that when it is low-water at Liverpool the stream of tide will begin and set in both St. George's and North Channels, and continue so setting for about six hours, therefore the ship will be affected by that tide, more or less, according to Neap or Spring tides; also in reference to where you are in the Channel, as to mid-stream, fairway, or to each side where it is stronger.

It will be easy to see that if I exactly stem the tide, I shall not be at the Tuskar as soon as I would be if there was no current; and I may also see clearly that I would be there sooner if the ebb current had been running out from Holyhead to Tuskar, or I might have half of each tide. In sailing vessels, according to the winds and other circumstances, I may have to watch the effects of several tides, and let them all be properly taken into account in order to know the whereabouts of the ship with some certainty.

TO FIND THE COURSE TO COUNTERACT A CURRENT.

Rule.—Draw the line (A B) to represent the course to make, and call (A) the ship's place; (B) her destination.

Set off from (A) the distance the Current runs in one hour, mark this (C); next take in the dividers the distance the ship is supposed to Log in one hour; place one leg of the dividers at (C), and let the other take the True Course at (B), then (C B) is the Course to keep her to make (A B) good, providing there is no change in the Current or rate of Sailing, which would require another projection.

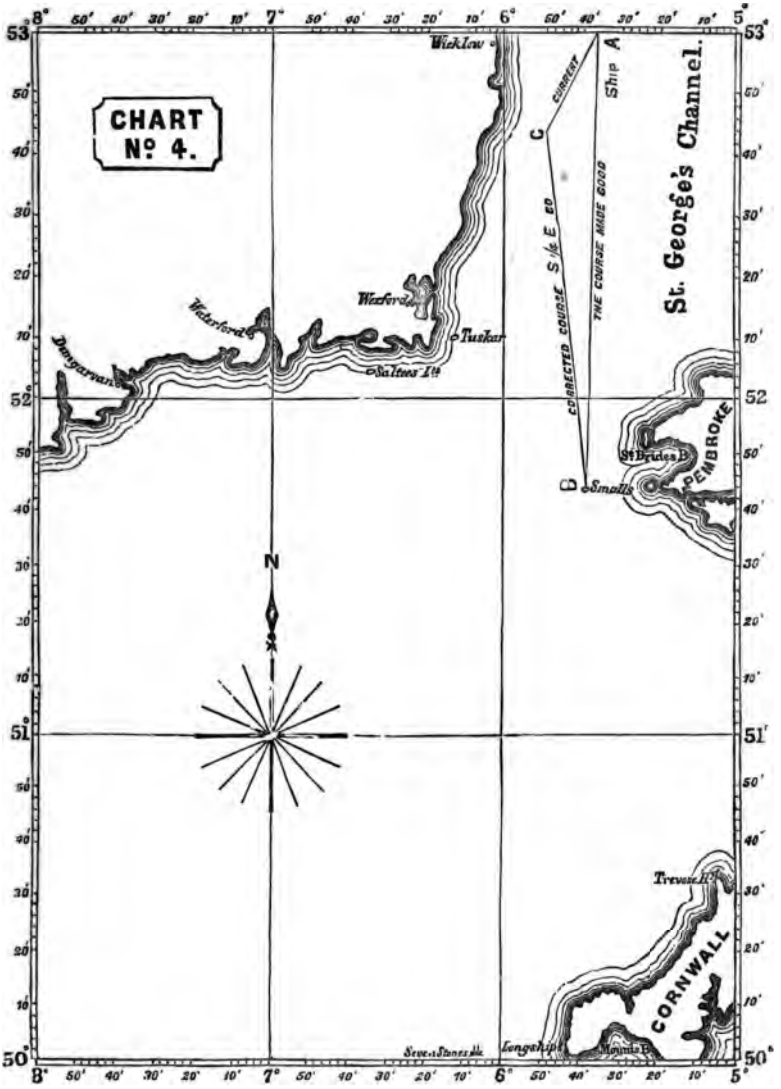
CHART
No. 4.
St. George's Channel.
Wicklow
Waterford
Wexford
Tuskar
Saltees Lt
Dungarvan
Ship A
CORRECT
C
S.½E. 20
CORRECTED COURSE
THE COURSE MADE GOOD
St Brides B
PEMBROKE
B
Smalls
N
Trevose Hd
CORNWALL
Longships
Lizard Pt
Scilly Isles
8°
7°
6°
5°
53°
52°
51°
50°

TABLE 1.

TO FIND THE LATITUDE BY AN ALTITUDE OF THE POLE STAR.

EXPLANATION.

Find the Right Ascension of the Meridian in one of the side columns; opposite, in the centre column, will be

To be *Subtracted* if the R.A. is found in this column.		THE CORRECTION.	To be *Added* if the R.A. is found in this column.	
H. M.	H. M.	° ′	H. M.	H. M.
7 10	19 10	0 0	7 10	19 10
7 00	19 20	0 3	7 20	19 00
6 50	19 30	0 7	7 30	18 50
6 40	19 40	0 11	7 40	18 40
6 30	19 50	0 15	7 50	18 30
6 20	20 00	0 18	8 00	18 20
6 10	20 10	0 21	8 10	18 10
6 00	20 20	0 25	8 20	18 00
5 50	20 30	0 29	8 30	17 50
5 40	20 40	0 32	8 40	17 40
5 30	20 50	0 36	8 50	17 30
5 20	21 00	0 39	9 00	17 20
5 10	21 10	0 42	9 10	17 10
5 00	21 20	0 45	9 20	17 00
4 50	21 30	0 48	9 30	16 50
4 40	21 40	0 51	9 40	16 40
4 30	21 50	0 54	9 50	16 30
4 20	22 00	0 56	10 00	16 20
4 10	22 10	0 59	10 10	16 10
4 00	22 20	1 02	10 20	16 00
3 50	22 30	1 04	10 30	15 50
3 40	22 40	1 06	10 40	15 40
3 30	22 50	1 08	10 50	15 30
3 20	23 00	1 10	11 00	15 20
3 10	23 10	1 13	11 10	15 10
2 50	23 30	1 17	11 30	14 50
2 30	23 50	1 19	11 50	14 30
2 10	0 10	1 21	12 10	14 10
1 40	0 40	1 23	12 40	13 40
1 10	1 10	1 24	13 10	13 10

TABLE II.

CORRECTION FOR SEMI-DIAMETER, DIP, PARALLAX, AND REFRACTION, TO BE *ADDED* TO THE OBSERVED ALTITUDE OF THE

MOON'S LOWER LIMB.

App. Alt. Moon's L.L.	Moon's Horizontal Parallax.							
	54′	55′	56′	57′	58′	59′	60′	61′
°	′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
10	59	1 00	1 01	1 02	1 03	1 05	1 06	1 07
15	59	1 01	1 02	1 03	1 04	1 05	1 07	1 08
20	59	1 00	1 01	1 02	1 03	1 05	1 06	1 07
25	58	59	1 00	1 01	1 02	1 03	1 05	1 05
30	56	57	58	59	1 00	1 01	1 03	1 04
35	54	55	56	57	58	59	1 00	1 01
40	51	52	53	54	55	56	57	58
42	50	51	52	53	54	55	56	57
44	48	50	51	52	53	54	55	56
46	47	48	49	50	51	52	53	54
48	46	47	48	49	50	51	52	53
50	45	46	47	47	48	49	50	51
52	43	44	45	46	47	48	49	50
54	42	43	44	44	45	46	47	48
56	40	41	42	43	44	45	45	46
58	39	40	40	41	42	43	44	44
60	37	38	39	40	40	41	42	43
62	36	37	37	38	39	39	40	41
64	34	35	35	36	37	37	38	39
66	32	33	33	34	35	36	36	37
68	31	31	34	33	33	34	35	35
70	29	30	32	31	31	32	33	33
72	27	28	28	29	29	30	31	31
74	25	26	27	27	28	28	29	29
76	23	24	25	25	26	26	27	27
78	22	22	23	23	24	24	25	25
80	20	21	21	21	22	22	23	23
82	18	19	19	19	20	20	21	21
84	16	17	17	17	18	18	19	19
86	14	15	15	15	16	16	17	17
88	13	13	13	14	14	14	15	15
90	11	11	11	12	12	12	13	13

TABLE II

CORRECTION FOR SEMI-DIAMETER, DIP, PARALLAX, AND REFRACTION, TO BE APPLIED TO THE OBSERVED ALTITUDE OF THE

MOON'S UPPER LIMB.

By ADDITION if + is prefixed, and by SUBTRACTION if — is prefixed.

App. Alt. Moon's U.L.	Moon's Horizontal Parallax.							
	54′	55′	56′	57′	58′	59′	60′	61′
°	′	′	′	′	′	′	′	′
10	+29	+30	+31	+31	+32	+33	+33	+34
15	30	31	31	32	33	33	34	35
20	29	30	31	31	32	33	33	34
25	28	29	29	30	31	31	32	32
30	26	27	28	28	29	29	30	31
35	24	25	25	26	26	27	27	28
40	21	22	23	23	24	24	24	25
42	20	21	21	22	22	23	23	24
44	+19	+20	+20	+21	+21	+21	+22	+22
46	18	18	19	19	20	20	20	21
48	17	17	17	18	18	19	19	19
50	15	16	16	16	17	17	17	18
52	13	14	14	15	15	16	16	16
54	12	13	13	13	14	14	14	14
56	11	11	11	12	12	12	13	13
58	9	10	10	10	10	11	11	11
60	+ 8	+ 8	+ 8	+ 9	+ 9	+ 9	+ 9	+ 9
62	6	6	6	7	7	7	7	7
64	4	5	5	5	5	5	5	6
66	3	3	3	3	3	4	4	4
68	1	1	1	2	2	2	2	2
70	— 1	0	0	0	0	0	0	0
72	2	— 2	— 2	— 2	— 2	— 2	— 2	— 2
74	4	4	4	4	4	4	4	4
76	— 6	— 6	— 6	— 6	— 6	— 6	— 6	— 6
78	8	8	8	8	8	8	8	8
80	10	10	10	10	10	10	10	10
82	12	12	12	12	12	12	12	12
84	13	13	14	14	14	14	14	14
86	15	15	16	16	16	16	16	16
88	17	17	17	18	18	18	18	19
90	19	19	19	20	20	20	20	21

TO FIND THE SET DRIFT AND RATE OF A CURRENT.

BY PROJECTION.

On the Chart, lay off from (A) ship's starting place, the course and distance sailed by log, and mark that (B). Next mark the ship's position by observation, either by cross bearings or latitude and longitude, which mark (C); then a line from A to C is the course and distance the ship has actually made, and B C must be the current.

For Example.

1871, June 4th, at 6 A.M., Ship, say half-a-mile to the Westward of the Smalls Lighthouse, (*Mark* A.) The wind East, close-hauled, laying N.N.E. and 2¼ Points West variation, making true N.¼W., going 10 knots to Noon, being 60 miles, puts the Ship at B by dead reckoning.

At Noon, I observe the Meridian Altitude of the Sun 59° 13′, which gives the Latitude 53° exactly, (*try it and see.*)

Now I find Wicklow Head bearing W.N.W. at Noon, being W.¼S. corrected, which, taken in the parallels and carried to Wicklow Head, will cross the parallel of 53° of Latitude at C, therefore B to C is the current.

Take B C in the parallels to the nearest Compass on the Chart, gives N.b.E.¾E., *true* 18 miles.

Then N.b.E.¾E. and 2¼ Points to the right gives the set of the current by Compass N.E., at the rate of 3 miles per hour.

On referring to the Admiralty Tide Tables for June 4th, at Liverpool, I find it High Water on that day $11^{h.}$ $44^{m.}$ A.M., therefore I must have had the whole flood from 6 A.M. to Noon, which accounts for the position of the Ship being at C.

Take another view of the case:—Suppose the whole ebb had been doing duty from 6 to Noon, and thick weather and no lead going, then it must be very clear that Blackwater Bank must have brought you up,—which just fancy with an Easterly fresh gale; Why, it's only a wonder that there is not more ships lost than there is on the Irish and Welsh Coasts!

You must study the directions given in the Admiralty Tide Tables for this St. George's Channel, if trading to Liverpool, or don't be astonished if you are surprised greatly some day.

See page 28 *for Shaping a Course in a Current, &c.*

HARBOUR LOG.

1871.	
SATURDAY, Sept. 16th.	Begins with fresh breezes from the westward, with squalls and rain at intervals. Received on board four tons of coal, thirty tierces mess beef, twenty casks of pork; bread, and bonded stores, &c., &c. Filled water tanks with fresh water, containing 6,000 gallons, and twenty casks containing 1,500 gallons. Finished loading cargo, caulked down and secured the hatches. Ship drawing 19 feet aft, and 18 feet 4 inches forward. Sounded pumps at five inches. Day ends more moderate, winds and cloudy weather.
SUNDAY Sept. 17th	Commences cloudy, with moderate breezes from the southward. Being Sunday, no work to report, except sounding pumps at five inches.
MONDAY, Sept. 18th.	Begins with cloudy weather, and fresh breezes from the S.E. Riggers employed getting cables on deck, anchors over, and range laid, and all other necessary preparations for proceeding to sea from the Pier Head. 10 A.M., pilot and crew came on board. At Noon, taken in tow by Steam Tug "Rattler." Day ends at Noon to begin Sea Log.

SHIP "*Royal Alfred,*" *John Bull, Esq.*, COMMANDER,

HRS.	KNTS.	FTHS	COURSES.	WINDS.	L.W.	REMARKS, TUESDAY, SEPTEMBER 19TH, 1871.
1						Fresh breezes and hazy weather.
2	5		W.N.W.	S.E.		2 P.M., discharged pilot off Bell Buoy.
3	6		"	"		Cast off steam tug, and made all plain sail.
4	7		"	"		
5	7		"	"		Crew employed clearing up decks and securing all moveable articles, and seeing all running gear in working order.
6	8		"	"		
7	8		"	"		
8	8		"	"		8 P.M., set the watches and pump'd ship at 6 inches. Skerries bearing S.b.W., 5 miles.
9	8		"	"		
10	9		"	"		
11	9	4	S.W.¼W.	S.E.b.E.		10 P.M., South Stack, bore E.S.E. by compass, 7 miles.
12	9	4	"	"		
1	9	4	"	"		Midnight, fresh breezes and clear.
2	9	4	"	"		
3	9	4	"	"		2 A.M., Bardsey Light bore E.b.S.½S. 15 miles.
4	9	4	"	"		
5	10		"	"		Passed several steamers inward bound.
6	10		"	"		
7	10		"	"		At 5H. 45M. A.M., the sun's centre bore E. 22° S. at rising for finding variation.
8	10		"	"		
9	10		"	"		
10	10		S.W.¼W.	E.S.E.		9 A.M., Smalls Lighthouse bearing East, 10 miles from whence the departure is taken.
11	10	4	"	"		
12	10	4	"	"		Noon, fresh breezes, &c., sun's mer. alt. 40°11′ S. Variation of the Compass 2¼ points West.

FINDING SHIP'S POSITION BY DEAD RECKONING.

CORRECTED COURSES.	DIST.	DIFFERENCE OF LATITUDE.		DEPARTURE.	
		N.	S.	E.	W.
S.5¾W.	10	"	4·3	"	9·0
S.2W.	31	"	28·6	"	11·9
True course S.32°W.	Dist. 39	D. lat.	32·9	Dep.	20·9

Latitude left (Small's Light).....	51° 43′ N.
Difference of latitude	— 33 S.
Latitude in.....	51 10 N.
Sum of latitudes	102 53
Middle latitude	51 26
Longitude left (Small's Light).....	5° 40′ W.
Difference of longitude	+ 33 W.
Longitude in.....	6 13 W.

RULE.—When the Latitude left and difference of Latitude are contrary names, subtract them, and call the Latitude in, same as the greater. When they are the same name, add them. Add the Latitude left and Latitude in together, and half them for the Middle Latitude. The Middle Latitude take as a course, and seek for the departure in a latitude column, against which, in the distance column, is the difference of Longitude.

The results obtained in the foregoing example would result in a similar state if worked in degrees instead of points.

FROM *Liverpool* TOWARDS *Australia.*

VARIATION OF THE COMPASS BY AMPLITUDE.

At 5H. 45M. A.M., the Sun's centre was observed to rise E. 22° S., the Latitude in being 52° N. Required the Variation of the Compass.

In Table 42 Norie, with Latitude 52°, and Sun's declination 2° N., the Sun's True Amplitude will be found to be.....	E. 3° 15′ N.
The Sun's Magnetic Amplitude at rising.....	E. 22 00 S.
Variation of the Compass.....	25 15 W.

When the Variation is found to exceed the Variation at the place of observation on the Chart, the overplus is deviation of the Compass, same name as the Variation.

When the Variation found is less than that per Chart, the deficiency *(or what it is short)* is deviation of a contrary name to the Variation, and for that point (*only*) of the Compass the Ship's head was at when the observation was made.

LATITUDE FROM THE MERIDIAN ALTITUDE OF THE SUN.

The Rule generally used is to take the observed altitude corrected for index error (*if any*) from 89° 48′, which is all very well when the eye is not over 12 feet above the level of the sea, and the altitude over 40°.

When the eye is 20 feet and the altitude is not above 40°, take the altitude from 89° 50′, which will be more correct than keeping to the old style of 89° 48′.

The Meridian Altitude in the day's work opposite was ...	40° 11′ S.
Eye being about 12 feet above the level of the sea.....	89 48
Sun's Meridian zenith distance.....	49 37 N.
Sun's declination, corrected by Table 21 Norie	1 33 N.
Latitude by observation, see Rules bottom page 180, Norie, or Ion's "Helps to Memory and Hand Book."	51 10 N.

The declination in Nautical Almanac for Sept. 19th is	1° 33′ 29″ N.
Correction, Table 21 Norie, for, Dec. 2° and Long. 6° W., is	— 0 24
Declination corrected for the Longitude of the Ship.....	1 33 05 N.

SHIP "*Royal Alfred*," *John Bull, Esq.*, COMMANDER,

HRS.	KNTS.	FTHS.	COURSES.	WINDS.	L.W.	REMARKS, WEDNESDAY, SEPTEMBER 20TH, 1871.
1	10	4	S.W.¼W.	E.S.E.		Commences with fresh breezes and clear.
2	10	4	,,	,,		Carrying all possible plain sail.
3	10	4	,,	,,		
4	10	4	,,	,,		
5	10	4	,,	,,		4 P.M. had sights for Chronometer, shewing 4h 21m 10s; which was fast 1m 30s for mean time at Greenwich. Sun's altitude L.L. 19° 41′ and Sun's magnetic bearing S. 91° 30′ W.
6	10	4	,,	,,		
7	10		,,	,,		
8	10		,,	,,		
9	10		,,	,,		
10	10		,,	,,		8 P.M. sounded pumps at 5 inches.
11	10		,,	,,		
12	10		,,	,,		
1	10		S.W.½W.	S.E.		Midnight, ditto weather.
2	10		,,	,,		
3	10		,,	,,		
4	10		,,	,,		
5	10		,,	,,		
6	10		,,	,,		
7	10		,,	,,		
8	10		,,	,,		
9	10		,,	,,		
10	10		,,	,,		
11	10		,,	,,		
12	10		,,	,,		Noon, Sun's meridian altitude 42° 30′ S. Variation 2¼ points West.

FINDING SHIP'S POSITION BY DEAD RECKONING.

CORRECTED COURSES.	DIST.	DIFFERENCE OF LATITUDE.		DEPARTURE.	
		N.	S.	E.	W.
S.2W.	123	,,	113·6	,,	47·1
S.2¼W.	120	,,	108·5	,,	51·3
True course S.24°W.	Dist. 243	D. lat.	222·1	Dep.	98·4

Latitude left	51° 10′ N.	
Difference of latitude 222′	= 3 42 S.	
Latitude in	47 28 N.	
Sum of latitudes	98 38	
Middle latitude	49 19	
Longitude left	6° 13′ W.	
Difference of longitude 150′	= 2 30 W.	
Longitude in	8 43 W.	

N.B.—In iron vessels, where deviation is an all-important matter, its introduction into a question similar to the above would in no way interfere with the principle of working, because deviation is applied in a similar manner to variation, viz., E. to the right hand, W. to the left.

FROM *Liverpool* TOWARDS *Australia.*

LONGITUDE BY CHRONOMETER.

At Noon previous, the Latitude by account and observation was ..... 51° 10′ N.
The Course 2 points and 42 miles, gives difference of Latitude 39 miles since Noon ..... — 39 S.

The Latitude of Ship when the sights were taken for Longitude by Chronometer ..... 50 31 N.

TIME BY CHRONOMETER. H. M. S.	ALTITUDE SUN'S LOWER LIMB.		SUN'S DECLINATION.	
September 19th 4 21 10		19° 41′	H.M.	1° 33′ 29″ N.
Fast for M. T. G. — 1 30	Cor. Table 9....	+ 9	Cor. for 4 20 & 2° decl.	— 4 18 Table 21 Norie
M. T. Greenwich 4 19 40	True altitude...	19 50	Sun's cord. declination	1 29 11 N.
	Latitude	50 31	0·19664	90
	Polar distance..	88 31	0·00015	
				88 31 Polar distance
	Sum	158 52		
	Half sum.....	79 26	9·26335	
	Remainder.....	59 36	9·93577	
		H. M. S.		M. S.
	App time at ship	3 59 23	= 9·39591 Table 31, Equa. time	6 9 Nautical Alm.
	Equa. of time...	— 6 13	Correction	+ 4 Table 51 Norie
	M. T. at ship...	3 53 10	Reduced Eqn. time..	6 13
	M. T. Greenwh.	4 19 40		
	Longitude.....	0 26 30	= 6° 37½′, West at 4 P.M.	

VARIATION BY AZIMUTH.			LATITUDE BY OBSERVATION.	
Sun's true altitude..	19° 50′	.. Secant 0·02656		89° 48′
Latitude.....	50 31	.. Secant 0·19664	Sun's meridian altitude.....	43 30 S.
Polar distance.....	88 31			
Sum	158 52		Zenith distance.....	46 18 N.
Half sum.....	79 26	.. Co Sine 9·26335	Sun's declination.....	1 10 N.
Remainder.	9 05	.. Co Sine 9·99452		
		19·48107	Latitude at end of the day.....	47 28 N.
	33° 23′	.. sine .. 9·74053		
	2			

True Azimuth..... S. 66 46 W.
Magnetic Azimuth S. 91 30 W. } Rules, p. 213 Norie, or Ion's Hand Book, page 52.

Variation..... 24 44 W.

BY AZIMUTH TABLES.

Latitude 51° N. and Sun's declination 2° N..... Apparent time at Ship, 4 P.M.	Gives Sun's true Azimuth	180° N. 113 W.	Page 214.
		or S. 67 W.	Burdwood's
Sun's Magnetic bearing at 4 P.M.		S. 91½ W.	Tables.
Variation of the Compass.....		24½ W.	

SHIP "*Royal Alfred,*" *John Bull, Esq.,* COMMANDER,

HRS.	KNTS.	FTHS.	COURSES.	WINDS.	L.W.	REMARKS, THURSDAY, SEPTEMBER 21ST, 1871.
1	11		S.W.¼W.	S.E.		Begins with fresh breezes, &c.
2	11		,,	,,		
3	11	4	,,	,,		
4	11	4	,,	,,		
5	11		S.W.½W.	S.E.		Passed several vessels standing to the N.E.
6	11		,,	,,		
7	11		,,	,,		Pumps carefully attended to.
8	11		,,	,,		
9	11		,,	,,		
10	11		,,	,,		Midnight, ditto weather.
11	11	4	,,	,,		
12	11	4	,,	,,		
1	12		S.W.	S.S.E.		
2	12		,,	,,		
3	12		,,	,,		
4	12		,,	,,		
5	12		S.W.b.W.	S.b.W.		Passed several vessels standing to the Eastward.
6	12		,,	,,		
7	11		,,	,,		8 A.M., altitude of the Sun's lower limb 21° 31′; time by the chronometer 8H. 38M. 22S. A.M.; and fast 1M. 31S. for mean time at Greenwich.
8	10		,,	,,		
9	9		W.S.W.	South.	½	
10	8		,,	,,		
11	8		,,	,,		
12	8		,,	,,		Noon, meridian altitude 46° 56′. S. Variation 2¼ points W.

FINDING SHIP'S POSITION BY DEAD RECKONING.

CORRECTED COURSES.	DIST.	DIFFERENCE OF LATITUDE.		DEPARTURE.	
		N.	S.	E.	W.
S.2¼W.	45	,,	40·7	,,	19·2
S.2W.	89	,,	82·2	,,	34·1
S.1¾W.	48	,,	45·2	,,	16·2
S.2¾W.	45	,,	38·6	,,	23·1
S.4W.	33	,,	23·3	,,	23·3
True course S.27°W.	Dist. 256	D. lat.	230·0	Dep.	115·9

Latitude left	47° 28′ N.
Difference of Latitude	3 50 S.
Latitude in at Noon	43 38 N.
	91 06
	45 33
Longitude left	8° 43′ W.
Difference of longitude	2 45½ W.
Longitude in	11 28½ W.

FROM *Liverpool* TOWARDS *Australia.*

LONGITUDE BY CHRONOMETER, &c.

	89° 48′
Meridian altitude..	46 56 S.
Zenith distance....	42 52 N.
Sun's declination...	0 46 N.
Latitude.....	43 38 N.

Latitude at Noon end of the day, September 21st 43° 38′ N.
Difference of latitude made from Noon back to 8 A.M. + 23 S.
Latitude reduced back to sights ..... 44 01 N.

TIME BY CHRONOMETER.

	H. M. S.
	8 38 22 A.M.
Fast.....	— 1 31
M. T. Greenw.	8 36 51 A.M.
Time from Noon	3 23

	M. S.
Equ.....	6 52
Co:.....	— 3
Redu. Equ.	6 49

ALTITUDE OF SUN'S LOWER LIMB.

	21° 31′
Correction.....	+ 10
True altitude.....	21 41
Latitude	44 01 ..
Polar distance.....	S9 10 ..
Sum	154 52 ..
Half sum.....	77 26 ..
Remainder	55 45

SUN'S DECLINATION.

	H. M.	0° 46′ 49″ N.
Cor. for 3 22	+ 3 20	
	0 50 09	
0·14319	90	
0.00005		
	89 10 Pol dis.	
9·33761		
9·91729		
9·39814		

	H. M. S.
Hour angle.....	4 00 04 =
	12
Apparent time at ship ..	7 59 56 A.M.
Equation of time.....	— 6 49
Mean time at ship.....	7 53 07 A.M.
Mean time at Greenwich	8 36 51 A.M.
Longitude.....	0 43 44 = 10° 56′ W. at 8 A.M. at ship

Difference of longitude + 32 made since 8 A.M.

Longitude in..... 11 28 W. at Noon.

N.B.—You will observe that the time being A.M. by Chronometer, what it wants of being Noon has been taken for getting the correction to the declination which has been added, because you see the previous declination in the Almanac larger, and you are working back from the Noon of the 21st.

The equation of time will also be corrected the same way by Table 51, daily difference 21s. and 3H. 22M. will give a correction of 2s. 9, say 3s, to be subtracted, because the equation of time is increasing, and you are working back.

Again, the departure made from 8 A.M. to Noon is shewn by last course in the Traverse Table.

SHIP *"Royal Alfred,"* *John Bull, Esq.*, COMMANDER,

HRS.	KNTS.	FTHS.	COURSES.	WINDS.	L.W.	REMARKS, FRIDAY, SEPTEMBER 22ND, 1871.
1	8		S.W.	W.N.W.	½	Begins with fresh breezes and clear weather, &c.
2	8		,,	,,		
3	8		,,	,,		
4	8		,,	,,		
5	8	4	S.W.½W.	N.W.		
6	8	4	,,	,,		6 P.M., the Sun's lower limb was observed on the horizon, when the chronometer shewed 6H. 46M. 21S., being fast for the mean time at Greenwich 1M. 31S. Sun's bearing by Compass W. 26° 30′ N.
7	8	4	,,	,,		
8	8	4	,,	,,		
9	8	4	,,	,,		
10	8	4	,,	,,		
11	8	4	,,	,,		Pumps attended to.
12	8	4	,,	,,		
1	8		S.S.E.	S.W.	½	Midnight, tacked ship.
2	8		,,	,,		
3	8		,,	,,		
4	8		,,	,,		
5	8		W.S.W.	South.	½	4 A.M., tacked ship.
6	8		,,	,,		
7	8	4	,,	,,		
8	8	4	,,	,,		
9	9	4	S.W.	S.E.		
10	9	4	,,	,,		
11	10		,,	,,		
12	10		,,	,,		Noon, meridian altitude 49° 25 S. Variation 2½ W.

FINDING SHIP'S POSITION BY DEAD RECKONING.

CORRECTED COURSES.	DIST.	DIFFERENCE OF LATITUDE.		DEPARTURE.	
		N.	S.	E.	W.
S.1¼W.	32	,,	30·6	,,	9·3
S.2W.	68	,,	62·8	,,	26·0
S.4½E.	32	,,	19·1	25·7	,,
S.4W.	33	,,	23·3	,,	23·3
S.1¾W.	39	,,	36·7	,,	13·1
True course S.15°W.	Dist. 179	D. lat.	172·5	Dep. 25·7	71·7 25·7 46·0

Latitude left ..... 43° 38′ N.
Difference of Latitude .... 2 52 S.

Latitude in at Noon ..... 40 46 N.
84 24
42 12

Longitude left ..... 11° 28½′ W.
Difference of longitude .... 1 02 W.

Longitude in ..... 12 30½ W.

FROM *Liverpool* TOWARDS *Australia.*

LONGITUDE BY CHRONOMETER AT SUNSET.

TIME BY CHRONOMETER.	H. M. S.
Sep. 21st	6 46 21
Fast	— 1 31
Mean time at Greenwich	6 44 50

SUN'S DECLINATION.	H. M. S.
	0 46 49 N.
Correction	— 6 40
	0 40 09
	90
	89 20 Polar dist.

EQUA. OF TIME.	M. S.
	6 52
Cor. + 5 Table 51	
	6 57

First corr. S. 1½ W. gives	30.6 S.	9.3 W.	Lat. at Noon 43° 38′ N.
Second do. S. 2 W. do.	15.7 S. =	6.5 W.	Diff. of lat. — 46 S.
Difference of latitude	46.3 S. dep.	15.8 W.	Lat. at 6 P.M. 42 52 N.

Long. 11° 28½′ W.
D. long + 21½ W.
Long. in 11 50 W. by ac.

Latitude	42° 52′	.. secant...	0·13493
Polar distance	89 20	.. co-sec..	0·00003
	132 12		
Subtract	— 21		
	2)131 51		
Half sum	65 55	.. co-sine..	9·61073
Add	+ 21	..	
Remainder	66 16	.. sine....	9·96162
	H. M. S.		
Ap. time at ship	6 04 27	.. Log.. .	9·70731
Equa. time	— 6 57		
M. T. at ship..	5 57 30		
M.T. at Greenh.	6 44 50		
	0 47 20	= 11° 50′ W. at 6 P.M.	

RULE.—From the sum of the latitude and Polar distance subtract 21′ and get the half sum, to which add 21′ for the remainder, and find the time by the usual Rules secant of the latitude, co-secant of the Polar distance, co-sine of the half sum, sine of the remainder.

N.B.—If the upper limb is observed subtract 53′, and add 53′ instead of 21′

VARIATION BY AMPLITUDE.

Latitude 43° and Sun's declination 1°, gives Table 42 true amplitude..	W. 1° 22′ N.
Sun's bearing by compass at setting (magnetic amplitude)	W. 26 30 N.
Variation of the compass by amplitude	25 08 W.

LATITUDE BY OBSERVATION.

Sun's meridian altitude	49° 25′ S.
	89 48
Sun's meridian zenith distance	40 23 N.
Sun's declination, corrected for longitude	0 23 N.
Latitude by observation	40 46 N.

Dec....	0° 23′ 26″ N.
Correc. —	47
Red. de.	0 22 39 N.

SHIP *"Royal Alfred,"* *John Bull, Esq.*, COMMANDER,

HRS.	KNTS.	FTHS.	COURSES.	WINDS.	L.W.	REMARKS, SATURDAY, SEPTEMBER 23RD, 1871.
1	11		S.W.¼W.	S.E.		Begins with fresh breezes and clear weather.
2	11		,,	,,		
3	11		,,	,,		
4	11		,,	,,		
5	11	4	S.W.¼W.	S.E.		
6	11	4	,,	,,		At 6H. 54M. 40S. P.M., by chronometer, the Moon's meridian altitude was 25° 04′ South; chronometer fast 1M. 32S.
7	11	4	,,	,,		
8	11	4	,,	,,		
9	11	4	,,	,,		
10	11	4	,,	,,		
11	11	4	,,	,,		
12	11	4	,,	,,		
1	12	4	S.W.¾W.	S.E.		Midnight, altitude of the Pole Star was 40° 10′.
2	12	4	,,	,,		
3	12	4	,,	,,		
4	12	4	,,	,,		
5	12		,,	,,		
6	12		,,	,,		
7	12		,,	,,		
8	12		,,	,,		
9	12		,,	,,		11H. 38M. A.M., altitude of the Sun's lower limb 52° 42′ S. for latitude by the reduction to the meridian.
10	12		,,	,,		
11	12		,,	,,		
12	12		,,	,,		Noon, Sun obscure. Variation 2 points West.

FINDING SHIP'S POSITION BY DEAD RECKONING.

CORRECTED COURSES.	DIST.	DIFFERENCE OF LATITUDE.		DEPARTURE.	
		N.	S.	E.	W.
S.2½W.	44	,,	39·8	,,	18·8
S.2½W.	92	,,	81·1	,,	43·4
S.2¾W.	146	,,	125·2	,,	75·1
True course S.29°W.	Dist. 282	D. lat.	246·1	Dep.	137·3

Latitude left	40° 40′ N.
Difference of Latitude	4 06 S.
Latitude in at Noon	36 40 N.
	77 26
	38 43
Longitude left	12° 31′ W.
Difference of longitude	2 57 W.
Longitude in	15 28 W.

FROM *Liverpool* TOWARDS *Australia.*

LATITUDE BY THE MERIDIAN ALTITUDE OF THE MOON'S LOWER LIMB.

GREENWICH TIME BY CHRO.	H. M. S.
Sept. 22nd.....	6 54 40 P.M.
Fast.....	1 32
M. T. at Greenh.	6 53 08

☽'s DEC. NAUTICAL ALMANAC.
At 6H.... = 24° 16′ 59″ S.
Cor. for 53M — 24
☽'s cor. dec. 24 16 35 S.

Diff. for 10M. = 4·48
53M = 53M. = 5 . 3
1344
2240
23,744

Moon's altitude	25° 04′ S.
Correction table II.	+1 03
Moon's true altitude.....	26 07
	90 00
Moon's meridian zenith dis...	63 53 N.
Moon's corrected declination..	24 17 S.
Latitude	39 36 N.

RULE.—To the mean time at Greenwich correct the Moon's declination as above. To the altitude of the Moon apply the correction for horizontal parallax and altitude, as directed at head of table II, which gives the Moon's true altitude; this taken from 90°, gives the zenith distance, from which, with the declination, get the latitude, as usual.

LATITUDE BY THE POLE STAR.

	H. M.
Time at ship.....	12 00
Sun's right ascension	11 58
Right ascension meridian	23 58

Star's apparent altitude.....	40° 10′
Correction for dip. and ref.	— 5
Star's true altitude.....	40 05
Correction from table I.	—1 20
Latitude at midnight	38 45 N.

LATITUDE BY THE SUN'S EX.-MERIDIAN ALTITUDE.

	H. M.
Time	11 38 A.M. at ship.
	12
Hour angle...	0 22
Sun's decl....	0° 0′
First correc..	0 Index No. (57)
	0 0

See explanation, foot of page 4, Towson's Tables.

Altitude of Sun's L.L.	52° 42′ S.
Cor. from Table 9.....	+ 12
Sun's corrected altitude	52 54
Correc. from Table 2, Towson.....	+ 21 for 53° and (57) Index No.
Sun's meridian altitude	53 15
	90
Sun's mer. zenith dist.	36 45 N.
Sun's declination.....	00 00
Lat. at 11H. 38M. A.M....	36 45 N.

SHIP *"Royal Alfred,"* *John Bull, Esq.*, COMMANDER,

HRS.	KNTS.	FTHS.	COURSES.	WINDS.	L.W.	REMARKS, SUNDAY, SEPTEMBER 24TH, 1871.
1	12		S.W.¼W.	S.E		Begins with fresh breezes and passing clouds.
2	12		,,	,,		
3	12		,,	,,		4 P.M. at Ship. When the chronometer shewed 5H. 2M. 33S., which was fast for the mean time at Greenwich 1M. 32S., the altitude of the Sun's lower limb was 22° 41′; the altitude of the Moon's lower limb 29° 58′, and the observed distance between the Sun and Moon's near limbs was 116° 10′ 30″, to find the longitude by chronometer, longitude by lunar, and the error of the chronometer. Index error of sextant, the distance was observed with — 3′ 09″.
4	12		,,	,,		
5	12		,,	,,		
6	12		,,	,,		
7	12		,,	,,		
8	12		,,	,,		
9	12		,,	,,		
10	12		,,	,,		
11	12		,,	,,		
12	12		,,	,,		
1	12		S.W.	S.E.		Midnight, ditto weather.
2	12		,,	,,		Pumps carefully attended to.
3	12		,,	,,		
4	12		,,	,,		
5	12		,,	,,		
6	12		,,	,,		Passed several vessels standing to the E.N.E.
7	12		,,	,,		
8	12		,,	,,		
9	12		,,	,,		Carrying all possible sail.
10	12		,,	,,		
11	12		,,	,,		
12	12		,,	,,		Noon, no observation. Variation 2 points West.

FINDING SHIP'S POSITION BY DEAD RECKONING.

CORRECTED COURSES.	DIST.	DIFFERENCE OF LATITUDE.		DEPARTURE.	
		N.	S.	E.	W.
S.2¼W.	144	,,	130·2	,,	61·6
S.2W.	144	,,	133·0	,,	55·1
True course S.24°W.	Dist. 288	D. lat.	263·2	Dep.	116·7

Latitude left	36° 40′ N.
Difference of Latitude	4 23 S.
Latitude in at Noon	32 17 N.
Longitude left	15° 28′ W.
Difference of longitude	2 21 W.
Longitude in	17 49 W.

FROM *Liverpool* TOWARDS *Australia*.

Latitude at Noon	36° 40′ N.	Sun's declination..	0° 00′ 03″ N.		M. S.
S. 2¼ W. 48, gives dif. lat.	— 43 S.	Correction Table 21	— 4 54	Equa. of time...	7 33½
				Correction for 5H. Table 51	+ 4½
Latitude in at 4 P.M. ...	35 57 N.		0 04 51 S.		
			90	Reduced eq. time	7 38
		Polar distance....	90 04 51		

Observed altde. Sun's L.L.	22° 41′			Rules for working time by Thomson's Tables, see problem 1., p. 6, of that work.
Correction Table 9.....	+ 10			
Sun's true altitude.....	22 51			
Latitude	35 57	.. Log 0·09177	Table 11, Thomson.	
Polar distance	90 05	.. Log 0·00000		
Sum	148 53			
Half sum	74 26	.. Log 4·42872	Table 12, Thomson.	
Remainder	51 35	.. Log 4·89405		
	H. M. S.			TIME BY CHRO.
Apparent time at ship..	4 5 07	.. Log 9·41454	Table 13, Thomson.	H. M. S. 5 2 33
Equation of time	— 7 38			fast 1 32
Mean time at ship.....	3 57 29			5 1 01 Sep. 23.
Mean time at Greenwich	5 01 01			
Longitude.....	1 03 32	= 15° 53′ West at 4 P.M.		

TO FIND THE APPARENT ALTITUDES AND THE APPARENT DISTANCE.

Sun's true altitude....	22° 51′	Alt. of Moon's L.L....	29° 58′	Observed dist....	116° 10′ 30″
Refraction, Table 6 ..	+ 2	Cor. for semi and dip.	+ 12	Index error.....	— 3 09
Sun's app. altitude...	22 53	Moon's app. altitude..	30 10	Cor. observed dist.	116 7 21
				Sun's semi-dia. ..	+ 15 59
				Moon's semi-dia...	+ 16 13
				Apparent distance	116 39 33

To find the true distance see Problem III., page 16, Thomson's Tables.

Moon's horizontal parlx...	58′ 57″	Log.. 0248	0248		
Sun's apparent altitude ..	22° 53′	Log.. 8702	Moon's apparent altitude	30° 10′...	7588
Apparent distance	116 39 33	Log S. 9512	Log T		1·2991
First correction	4 34 21	Log 1·8462			
Second correction	4 45 07	.....			Log 2·0827
Third correction	+ 2 58				
True distance — 10°.....	116 01 59	To find the Greenwich time, see Problem IV. page 14, Thomson.			
Dist. at 3H. Nautical Alk.	114 56 29	Pro. Log, Naut. Alk.	2666	Take this Log from the one under always.	
Difference	1 05 30	Pro. Log Table 19....	4390		
Proportional part of time	2 01 01	Pro. Log Table 19....	1724		
Time over first distance..	3 0 0	In Nautical Almanac.			

				H. M. S.
Mean time at Greenwich..	5 01 01	.....	Mean time at Greenwich by Lunar	5 01 01
Mean time at Ship	3 57 29		Chronometer shewed	5 02 33
Longitude in time.....	1 03 32	= 15° 53′ W.	Chronometer fast.....	0 1 32

SUPPLEMENT.

Inspection Method of finding the course and distance between two places, the Latitude and Longitude of which are given.

RULE.—Get the difference of Latitude, Meridional Parts, (table 3) and the difference of Longitude in miles.

Latitudes same name subtract for the difference of Latitude, contrary add. The Meridional Parts follow the same rule.

Longitudes same name subtract; one East and the other West, add them, and if the sum exceeds 180° take it from 360° for the difference of Longitude.

Example.

Lat. of Ship at Noon..	48° 28′ N.	Meridional Parts	3334	Longitude	5° 03′ W.
Lat. of place bound to	37 44 N.	Meridional Parts	2448	Longitude	25 40 W.
Difference of Lat.....	10 44	Mer. Diff. Latitude ..	886	Diff. Longitude ..	20 37
	60				60
In Miles.....	644			In Miles.....	1237

Seek for a tenth of the difference of Longitude in a departure column, and a tenth of the Meridional difference of Latitude in a latitude column, and where they are found to agree nearest, will shew the course at top of table when the Meridian difference Latitude is the greater; when the difference Longitude is the greater, the course is found at the foot of the table, see the following

Example.

TO FIND THE COURSE.

Difference of Longitude $\frac{1}{10}$th* 123·7 in a dep. col. } Gives Course S. 54° W. † Table 2, Norie.
Meridional diff. of Latitude.. 88·6 in a lat. col. }

Note the going from 48° N. Latitude to 37° N. shews the ship has to make Southing, and the Longitudes shew she has to make Westing, hence the Course S. and W.

Rule for finding the distance,—take the same Course, 54°, and seek for the difference of Latitude in its own column, and the distance against it in a distance column is the distance required.

Example.

Course found	54°	} Gives in the distance column	109 Miles.
$\frac{1}{10}$th Difference of Latitude	64.4	} Multiply by	10
		The whole distance	1090

It must be seen that 644 miles is too great for finding in the tables, then it had to be divided by 10 to get it small enough, and the 64·4 giving only a tenth of the distance, 109, it had to be multiplied by 10 to get the distance wanted, viz. 1090.

* One-tenth of any number is to cut off the last figure and let it remain a decimal.

† It may not be amiss to remind you that the course found is the true course, to the right hand of which Westerly variation must be allowed to get the course to sail; for Example—S. 54° W. is equal to S.W. $\frac{3}{4}$ W. (*nearly*) then 2¼ Westerly variation would make S.W. $\frac{3}{4}$ W. into the course to sail W. by S. (*Mind that.*) Easterly variation goes to the left of the true course for the Compass course.

Deviation of the Compass follows the same rule, Westerly to the right of the true for the Compass course, Easterly to the left hand.

On a voyage from England to Australia, by way of the Cape of Good Hope, and thence to England again by way of Cape Horn, the ship by sailing Easterly round the Earth, gains an entire day (24 hours). If you ask how is that, why just reflect how you have been putting your watch forward, according to the Easting you have made daily, and if the watch is keeping anything like correct time, your putting it forward is gradually making the day up, that we have already stated you will gain by sailing round the World.

Well now, what must be the consequence of this, when arriving at 180° East Long. on the return voyage. Surely you see that you have put the watch ahead 12$^{h.}$ since leaving England, as you made Easting, and 180° is 12 hours, therefore you have shoved time on faster than it went (*did you not?*); then you must make some allowance for what has been done, in order to come out right on your arrival in England, if not, you will be calling it Sunday when it is only Saturday in England, and it is so, because you have made it so by fleeting the watch forward.

Now, to rectify all this when on the voyage homewards, you reach 180° East Longitude, say on a Friday, by Ship's Log, then the next day you write Friday again (*two Fridays*), instead of Saturday (*mind that*), then when you arrive in England you will find you have the same day as the *Natives* have.

But you may still say, that when arriving at 180° East I have only put the watch forward 12 hours; well, so it is, you have only gained 12 hours, but if you will go on, you will gain the other 12 by the time you reach England, and that will be the 24, *won't it.*

Take an example of this kind, for illustration; say it is noon to-day at Greenwich, where we shall fancy we are just now. Then look at some place to the Eastward, say 30° East, why you know it must be 2 o'clock in the afternoon of the day there, when noon at Greenwich (*is it not so? Of course it is*). Also look at some place to the West of Greenwich, say 30° West Longitude, why you know very well that if it is noon at Greenwich, it will not be noon there for 2 hours yet, and consequently, must be 10$^{h.}$ A.M., or 22$^{h.}$ of the day before that day which is beginning now at Greenwich, or that has already began, and going on, in East Longitude. So much then for going round the World in an Easterly direction: keep the same day twice, when you arrive at 180° East, and you will come out all right at the end.

SHIP "*Royal Alfred*," *John Bull, Esq.*, COMMANDER,

HRS.	COURSE.	KNTS.	FTHS.	WINDS.	L.W.	REMARKS, FRIDAY, OCTOBER 20TH, 1871.
1	E.$\frac{1}{2}$N.	10		West.		Begins with fresh breeze.
2	"	10		"		
3	"	10		"		
4	"	10		"		
5	"	10		"		
6	"	10		"		
7	"	10		"		
8	"	10		"		
9	"	10		"		Midnight, fresh breeze.
10	"	10		"		
11	"	10		"		
12	"	10		"		
1	"	10		"		
2	"	10		"		
3	"	10		"		9 A.M. observed altitude Sun's lower limb 32° 30′.
4	"	10		"		Time by chronometer, October 19th, =
5	"	10		"		8H. 42M. 49S. P.M., which was slow 1M. for
6	"	10		"		mean time at Greenwich.
7	"	10		"		
8	"	10		"		
9	"	10		"		
10	"	10		"		
11	"	10		"		Meridian altitude 44° 32′ N.
12	"	10		"		Variation 1 point Easterly.

TRUE COURSE.	DIST.	N.	S.	E.	W.
E.$\frac{1}{2}$S.	240	"	11.8	239·7	"
E.$\frac{1}{2}$S.	240	D.Lat.	11.8	239·7	Dep.

Lat. yesterday, 55° 10′ S. Longitude 174° 12′ E.
Diff Lat. .... + 12 S. Diff. Long. 6 58 E.
Lat. at Noon .. 55 22 S. Longitude 181 10 E.
360 00
Longitude in 178 50 W.

FROM *Australia* TOWARDS *Liverpool.*

Latitude at Noon ..... 55° 22′ S.
Dis. since 9H. = 30 Miles, gives Diff. Lat. 2 S. and dep. 30′ gives Diff. Long. 52′ E.

Latitude in at sights ..... 55 20 S.

	H. M. S.				
Time by Chron. 19th	8 42 49 P.M.	Alt. ⊙'s	..32° 30′	Sun's dec. 9° 55′ 45″ S.	H. diff. 54″·34
Slow	+ 1 00			Correc. .. + 7 58	Gh. time 8 · 7
October 19th	8 43 49 P.M.			Red. dec. 10 3 38	38038
					43472
				Pol. dis. 79 56 00	47,2,758
					Correc. 7 58

				M. S.	
Obsd. Altitude	32° 30′			Eq. of time	14 54 ·45
Cor. Table 9, Norie ..	+ 10			Correction	+ 4 8·7
True altitude..	32 40			Cor. Eq. ..	14 58 315
Latitude	55 20	Log secant..	0·24504		360
Polar distance	79 56	Log co-secant	0·00674		Correc. 3,915
Sum	167 56				
½ Sum	83 58	Log co-sine ..	9·02163		
Remainder	51 18	Log sine	9·89233		
	H. M. S.				
Time from Noon ..	3 0 1	Log Table 31,	9·16574		
	12				
App. time at Ship ..	8 59 59 A.M.				
Equation of time ..	— 14 58				
October 20th	8 45 01 A.M. at Ship.				
October 19th	8 43 49 P.M. at Greenwich.				

Latitude in time .. 12 01 12 Table 19 = 180° 18′ E., because Greenwich time is least.
360 00

Longitude .. 179 42 W. at 9H. A.M.
Run since .. — 52 E.

Longitude .. 178 50 W. at Noon.

Meridian altitude..... 44° 32′ N. Declination..... 10° 17′ 11″ S.
89 48 Cor. for Long.... — 10 46 for 180° E

Zen. distance ..... 45 16 S. Sun's declination 10 6 25 S.
Declination ..... 10 6 S.

Latitude at Noon..... 55 22 S.

SHIP *"Royal Alfred,"* *John Bull, Esq.*, COMMANDER.

HRS.	COURSE.	KNTS.	FTHS.	WINDS.	L.W.	REMARKS, FRIDAY, OCTOBER 20TH, 1871.
1	E.¾N.	10		West.		Begins with fresh breeze.
2	,,	10		,,		
3	,,	10		,,		Having crossed the Meridian of 180° E., we must call this day the same day and date as yesterday.
4	,,	10		,,		
5	,,	10		,,		
6	,,	10		,,		
7	,,	10		,,		
8	,,	10		,,		
9	,,	10		,,		
10	,,	10		,,		
11	,,	10		,,		
12	,,	10		,,		
1	,,	10		,,		
2	,,	10		,,		9 A.M., time by chronometer 8H. 10M. 57S. P.M., 20th, which was slow 1M. 1S. for mean time at Greenwich.
3	,,	10		,,		
4	,,	10		,,		
5	,,	10		,,		Observed Sun's altitude 32° 10′.
6	,,	10		,,		
7	,,	10		,,		
8	,,	10		,,		
9	,,	10		,,		
10	,,	10		,,		
11	,,	10		,,		Meridian altitude 44° 29′ N.
12	,,	10		,,		Variation 1¼ points Easterly.

TRUE COURSE.	DIST.	N.	S.	E.	W.	
E.¼S.	240	,,	23·5	238·8	,,	Latitude..55°22′ S. Longitude..178°50′ W. Diff. Lat...+ 24 S. Diff. Long.. 7 01 E.
						Latitude.. 55 46 S. Long. in .. 171 49 W.
E.¼S.	240	D. lat.	23·5	238·8	Dep.	

FROM *Australia* TOWARDS *Liverpool.*

Latitude at Noon ... 55° 46′ S.
3H. = 30 miles.. = 3 S. and 29·9 = 52′ longitude

Latitude at sight .... 55 43 S.

	H. M. S.				
October 20th,....	8 10 57 P.M.	Altitude ⊙'s	32°10′	Declination..	10°17′ 25″ S.
Slow.....	1 1			Correction ..	+ 7 23
Oct. 20th	8 11 58 P.M.	at Greenwich.		Cor. decl.....	10 24 48 S
Obs. altitude....	32°10′			Polar distance	79 35
Correc., Table 9	+ 10				
True altitude....	32 20				
Latitude	55 43	Log secant	0·24927		
Polar distance ..	79 35	Log co-sec.	0·00722		
Sum	167 38				
Half sum.....	83 49	Log co-sine	9·03226		
Difference	51 29	Log sine ...	9·89344		
	H. M. S.				
Time from Noon	3 3 39	= Log Table 31	9·18219		
	12				

H. diff.		53·97
		8·2
		10794
		43176
		44·2554
Cor.		7·23
	M. S.	
Equation of time	15 5	43
Correction	+ 3	8·2
Equation correc.	15 8	86
		344
Cor.		3·526

Ap. T. at ship 20th 8 56 21 A.M.
Equation of time — 15 8

M.T. at ship 20th 8 41 13 A.M.
M.T. Green. 20th 8 11 58 P.M.

Longitude .... 11 30 45 = 172° 41′ W. at 9H. A.M.
Diff. long. — 52 E. made since 9 A.M.

Longitude 171 49 W. at Noon.

Meridian altitude..... 44°29′
89 48

Zenith distance..... 45 19 S.
Sun's declination..... 10 27 S.

Latitude..... 55 46 S.

Declination ..... 10°17′11″ S.
Longitude ..... + 10 14 for longitude 171° W.

Sun's declination 10 27 25 S.

Take another view of going round the World: say in a Westerly direction, the opposite effect must be produced, viz., going West you are constantly putting the watch back (*are you not?*), because you get to a place by sailing West where the time is less than what the watch will shew, therefore put it back you must, and by putting it back you lose time, or going back to the day previous; therefore you will lose as much at 180° West—viz., 12 hours—as you gained going East at 180° East, 12^h; consequently, going round the World Westerly, it will be necessary, when you arrive at 180° West, to jump two days ahead,—that is to say, when I arrive at 180° West on Friday the 20th October, I must say Sunday the 22nd for the Log of next day, or I will find on arriving in England again by a Westerly route, that I am Saturday and they Sunday. Of course it must be so; then jump over a day, going West when you reach 180° West, so as to be square and right with your friends, or you may be asking them if they were going to Church or Chapel, thinking it is Sunday, when they will tell you that they attended there (*as usual*) yesterday; and they will be rather astonished at your amazement, or perhaps think that you may be troubled with aberration of mind, and have some serious thoughts of having you looked after for safety, &c.

Some illustration of different dates may be seen from another point of view: say this is Saturday Night in England, 10 o'clock, and just going to turn in (*if not too early*); now look back to the Eastward as far as Melbourne or China, and you will find them going to breakfast on Sunday Morning, just at the same instant of time as you turn in here on Saturday, two different days altogether; and unless the days are changed at 180° of Longitude, you will find by going round the World you will differ in the day of the week either one before or one behind them in England, just according as you went Westerly or Easterly. Then consider this matter, until well understood, in order that there may be no misgivings when you are required to put this into practice; and in case you don't see the thing clearly, remember this—that it is Saturday with some of the inhabitants of the globe and Sunday at the same time with others, and if you keep going round the World (*going Easterly*), you that have Saturday will have somewhere to jump into Sunday, otherwise you will remain a day behind as you are without such a jump.